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MEMORANDUM REPORT NO. 2385

KINEMATIC STUDY OF THE 7.62mm SOVIET MACHINE GUN, SHKAS

Timothy L. Brosseau

May 1974

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER MEMORANDUM REPORT NO. 2385	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* KINEMATIC STUDY OF THE 7.62mm SOVIET MACHINE GUN, SHKAS		5. TYPE OF REPORT & PERIOD COVERED MEMORANDUM REPORT
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Timothy L. Brosseau		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Ballistic Research Laboratories Aberdeen Proving Ground, Maryland 21005		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Materiel Command 5001 Eisenhower Avenue Alexandria, Virginia 22333		12. REPORT DATE MAY 1974
		13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

7.62mm Soviet Machine Gun, Shkas
trunnion forces
displacement vs time
rate of fire
muzzle velocity
cycle time

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* amb

A kinematic study was performed on the 7.62mm Soviet Machine Gun, known as the "Shkas", to determine if the weapon is capable of firing at 2000 rds/min (33.33 rds/s). Forces at the trunnions, displacements of the weapon components rates of fire, and velocity at the muzzle were measured. Results showed that the weapon is capable of firing at 2000 rds/min (33.33 rds/s); however, the horizontal trunnion forces are excessive at this high rate of fire.

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I. INTRODUCTION

The U. S. Army Small Arms System Agency requested that the Interior Ballistics Laboratory perform a kinematic test on a Soviet machine gun known as the "Shkas". The specific purpose of the test was to determine if the weapon functions at 2000 rds/min (33.33 rds/s) and to evaluate the mechanism by which it achieves its high rate of fire.

II. DESCRIPTION OF WEAPON TESTED

A. General Description

The Shkas is a 7.62mm automatic weapon. It is gas-operated and belt-fed, and has a nominal rate of fire of 1000 rds/min (16.67 rds/s) to 2000 rds/min (33.33 rds/s) depending on the size of the gas orifice selected. The driving element of the weapon is the bolt carrier which slides in a very massive receiver. The bolt carrier operates the rotary feed mechanism, the drop bolt, the ejector mechanism, and the firing pin. The complete weapon, as shown in Figure 1, weighs 23.0 lb (10.4 kg).

Figure 1. 7.62mm Shkas Machine Gun

B. Nomenclature

The nomenclature of the parts of the weapon is presented in the following figures and descriptions.

Figure 2. Barrel Assembly

1. Barrel Assembly. The barrel assembly shown in Figure 2 weighs 6.0 lb (2.7 kg). It contains the adjustable front sight and the gas cylinder. A rotating gas orifice plug is located in front of the gas cylinder which allows the selection of different size gas ports to change the rate of fire.

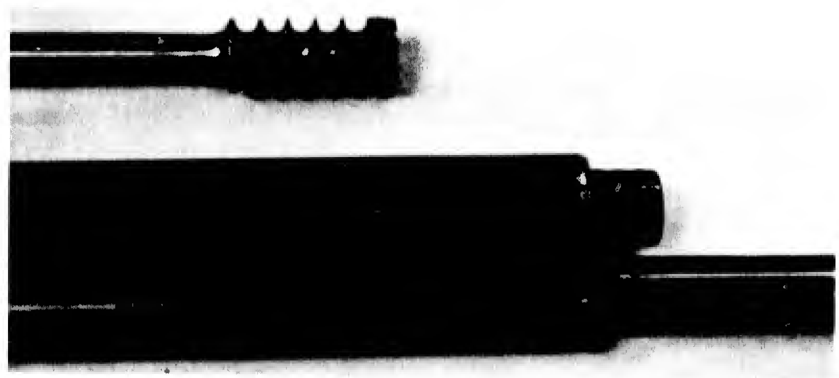

Figure 3. Gas System

2. Gas System. The gas system shown in Figure 3 is a conventional piston and cylinder type, with venting occurring after the piston has moved rearward 3.6 in. (91 mm). The port hole in the gun barrel is 0.200 in. (5.08 mm), but a rotating gas orifice plug positions one of three hole sizes in front of the gas port. The three hole sizes are 0.113 in. (2.87 mm), 0.097 in. (2.46 mm), and 0.077 in. (1.95 mm) in diameter. The gas piston is attached rigidly to the bolt carrier. The diameter of the gas piston is 0.702 in. (17.83 mm).

Figure 4. Bolt Carrier

3. Bolt Carrier. The bolt carrier shown in Figure 4 slides freely in machined grooves in the receiver. The bolt carrier contains the bolt assembly, firing pin, and drive spring.

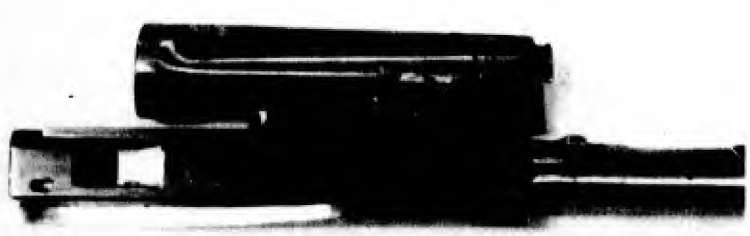

Figure 5. Bolt Assembly

4. Bolt Assembly. The bolt assembly shown in Figure 5 is a drop bolt type of lock. The bolt is dropped when a cam on the bolt carrier

slides up a ramp machined inside the bolt body. The rear edge of the bolt is forced down and locks into a slot machined into the receiver, as shown in Figure 6.

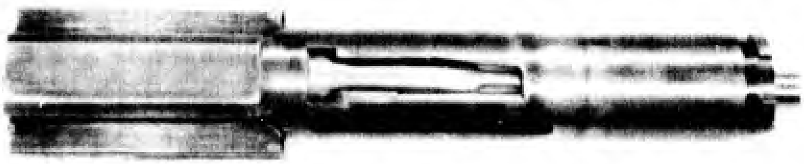

Figure 6. Locking Slot

Figure 7. Firing Pin

5. Firing Pin. The firing pin shown in Figure 7 is located inside the body of the bolt assembly. The firing pin floats in the bolt assembly and is struck by the bolt carrier at the end of its forward travel.

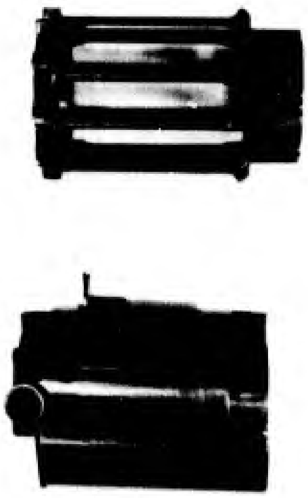

Figure 8. Feed Mechanism

6. Feed Mechanism. The feed mechanism shown in Figure 8 is a rotating, cylindrical, cage-type mechanism. The cage is rotated by an indexing lever that is driven by a cam machined on the bolt carrier, as shown in Figures 9 and 10.

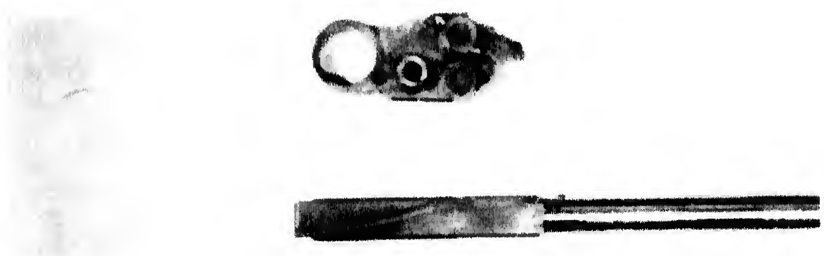

Figure 9. Indexing Lever and Drive Cam

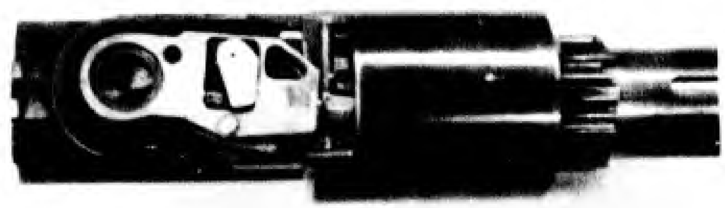

Figure 10. Indexing Lever Engaged in Feed Cage

A helical groove around the inside surface of the shroud covering the cage engages the rims of the cartridge cases and withdraws the cartridges rearward out of the links, as shown in Figure 11.

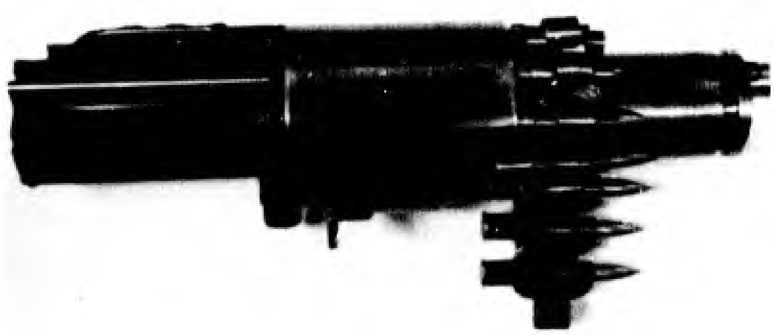

Figure 11. Linked Rounds in Feed Cage

The cylindrical cage holds ten rounds and requires several cycles of bolt carrier motion to completely delink a round and place it in the bottom of the receiver for chambering.

Figure 12. Extractor

7. Extractor. The extractor shown in Figure 12 consists of a machined slot in the face of the bolt. As the bolt carrier moves forward, the rim of the cartridge is forced up into the machined slot by a spring-loaded finger shown in Figure 13.

Figure 13. Spring-loaded Finger

The rim of the case is held in the machined slot by a pivoting stop that is forced into position by the side of the receiver as the bolt moves through it.

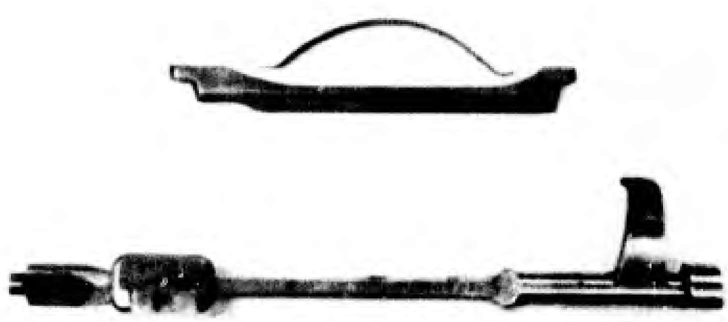

Figure 14. Ejector System

8. Ejector. The ejector system shown in Figure 14 is a pivoting-lever type of mechanism. The lever is rotated by a torque applied to the shaft supporting the lever. The torque is applied to the shaft by means of the cam and follower that is actuated by the bolt carrier as it reaches the end of its stroke, as shown in Figure 15.

Figure 15. Ejector Cam and Follower

The end of the pivoted lever strikes the spent case 0.6 in. (15 mm) from the rim end of the case and forces the round into a channel along the left side of the receiver. The case is held in the channel by a spring-loaded guide, as shown in Figure 14. The case is pushed out of the channel and ejected out the front of the receiver by the bolt carrier as it moves forward.

Figure 16. Drive Spring

9. Drive Spring. The drive spring shown in Figure 16 consists of a double-strand, helical-wound spring that is contained inside the operating rod. The operating rod, with the inclosed drive spring, slides over the push rod shown in Figure 17 which is latched to the rear of the receiver.

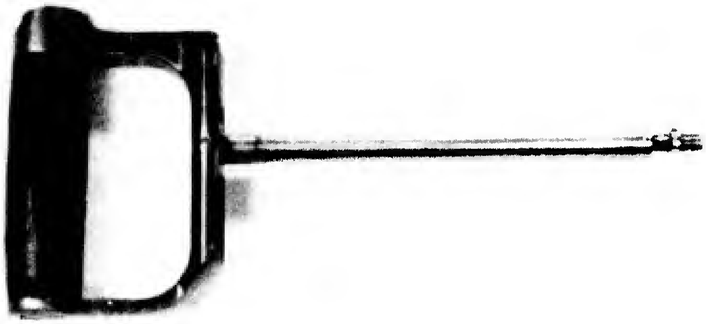

Figure 17. Push Rod

The rod is unlatched from the receiver and pulled rearward to recharge the weapon. The drive spring has a spring constant of 8.5 lb/in. (1.48 kN/m) and a preload of 20.0 lb (89.0 N).

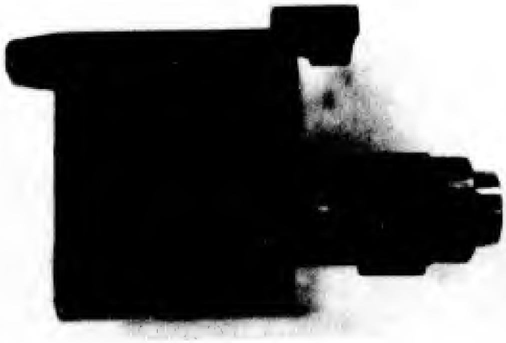

Figure 18. Buffer Assembly

10. Buffer Assembly. The buffer assembly shown in Figure 18 consists of two square wire helical springs. One spring with a spring constant of 625 lb/in. (109 kN/m) and a preload of 75 lb (334 N) acts against the bolt carrier. The other spring with a spring constant of 3500 lb/in. (612.9 kN/m) and a preload of 250 lb (1.11 kN) acts against the bolt. The total travel allowed by the buffer springs is 0.235 in. (5.97 mm).

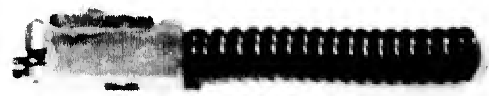

Figure 19. Sear Assembly

11. Sear Assembly. The sear assembly shown in Figure 19 consists of a spring-loaded, pivoted sear contained in a block. The sear engages a slot on the right side of the bolt carrier to hold the bolt carrier in the charged position. The block containing the sear, shown in Figure 20, is also spring-loaded so that the sear and block can travel forward when the sear reengages the bolt carrier to help reduce the forces on the sear.

Figure 20. Sear Assembly in Receiver

III. TEST CONDITIONS

To determine the rate of fire of the Shkas and to evaluate the mechanism by which it achieves its high rate, a kinematic study was conducted under standard operating conditions. The weapon was mounted in a rigid trunnion mount while firing twenty-round bursts with a lubricated mechanism. The weapon used for the test was obtained from the Ordnance Museum and could not be modified, so therefore only a limited number of measurements could be taken.

IV. MEASUREMENTS, TEST EQUIPMENT AND PROCEDURES

A. Trunnion Forces. The rigid trunnion mount consisted of three sets of trunnion gages which supported the weapon as shown in Figure 21.

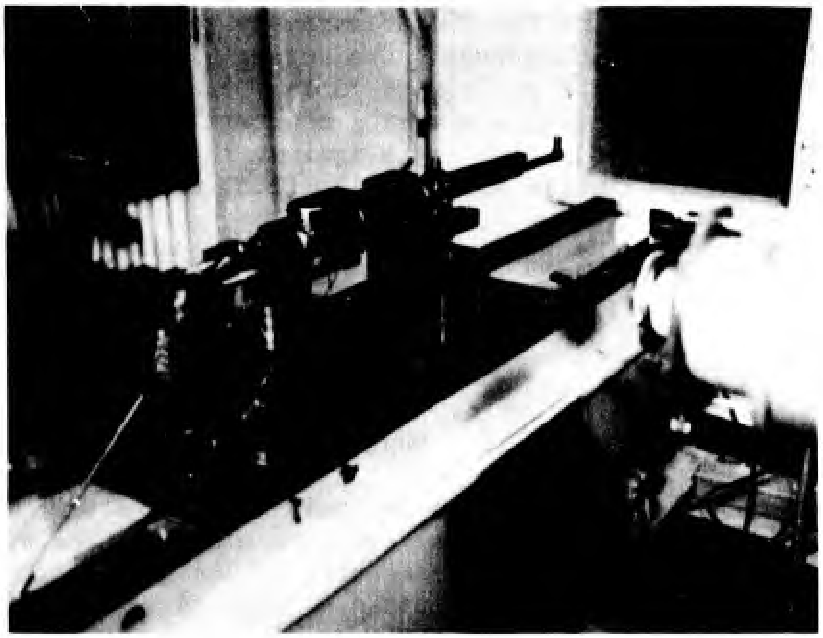

Figure 21. Rigid Trunnion Mount

The gages were thin-walled ferrules to which standard foil-type strain gages were mounted. Both horizontal and vertical forces were measured during firing. The positions of the trunnion gages are shown in Figure 22.

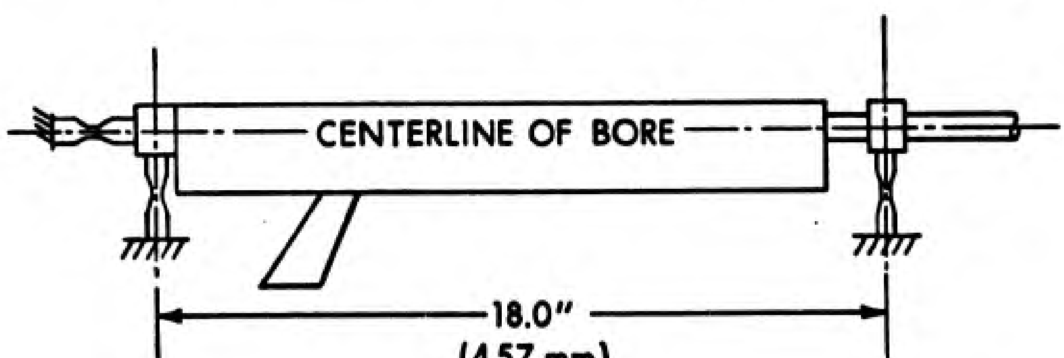

Figure 22. Trunnion Gage Locations

The front vertical trunnion gages were placed at the front trunnion pins which held the weapon when mounted in an aircraft. The trunnion forces were recorded on a Honeywell Magnetic Tape System.

B. Displacement versus Time of Bolt Carrier and Receiver. The horizontal motion of the bolt carrier and the receiver were recorded with a displacement-time camera during firing. The camera can be seen in Figure 21.

C. Muzzle Velocity. Muzzle velocity was measured by placing three Lumiline Screens downrange, 12 ft (3.7 m) apart.

D. Rate of Fire. The rate of fire was measured from the cycle time on the displacement-time records, and also by the round-to-round time intervals, as sensed by a Lumiline Screen and recorded by the electronic counter and printer.

V. RESULTS

A. Trunnion Forces. Figure 23 shows the trunnion forces and bolt carrier displacement during a single firing cycle from a lubricated weapon. The average maximum trunnion forces and standard deviations are given in Tables IA and IB. The horizontal forces are larger than the vertical forces in all cases. The bolt carrier displacement and horizontal force records show that the maximum horizontal force occurs when the bolt carrier strikes the buffer. The collision between the bolt carrier and the buffer is very severe and, as a result, the horizontal trunnion forces at this point are very large. Tables IA and IB also show that the trunnion forces are much larger for the last ten rounds in the twenty-round burst than for the first ten rounds. The reason for this is that the feed system requires ten rounds to be positioned around the feed cage in varying stages of delinking. Therefore, as the eleventh round of the twenty-round burst is fired, there are no new rounds left for the feeder to start delinking and the energy required for feeding decreases. This increases the energy left in the bolt carrier which increases the horizontal trunnion forces, the rate of fire, and the buffer compressions. The maximum horizontal forces measured with stripping occurring averaged 1000 lb (4.45 kN) less than with the rounds free in the cage with no stripping occurring.

B. Displacement versus Time Records. Figure 24 shows a typical bolt carrier displacement versus time record with the sequence of several functions of operation labeled. This record is typical for the first ten rounds fired in a twenty-round burst from a lubricated weapon.

C. Rate of Fire. The rate of fire was obtained by measuring the time elapsed during each cycle in the bursts on the displacement versus time records of the bolt carrier. This rate was also measured for each round in the burst by the electronic counter and printer. The average cyclic rates and standard deviations are given in Tables IIA and IIB. These data show that the rate of fire for the first ten rounds of the twenty-round burst averages 200 rds/min (3.33 rds/s) less than the rate of fire for the last ten rounds.

D. Buffer Compression. The distances the buffers were compressed were measured from the displacement versus time records of the bolt carrier. The average buffer compressions and standard deviations are given in Tables IIIA and IIIB. The bolt carrier compressed the buffers in all conditions, but under no conditions were the buffers compressed to their

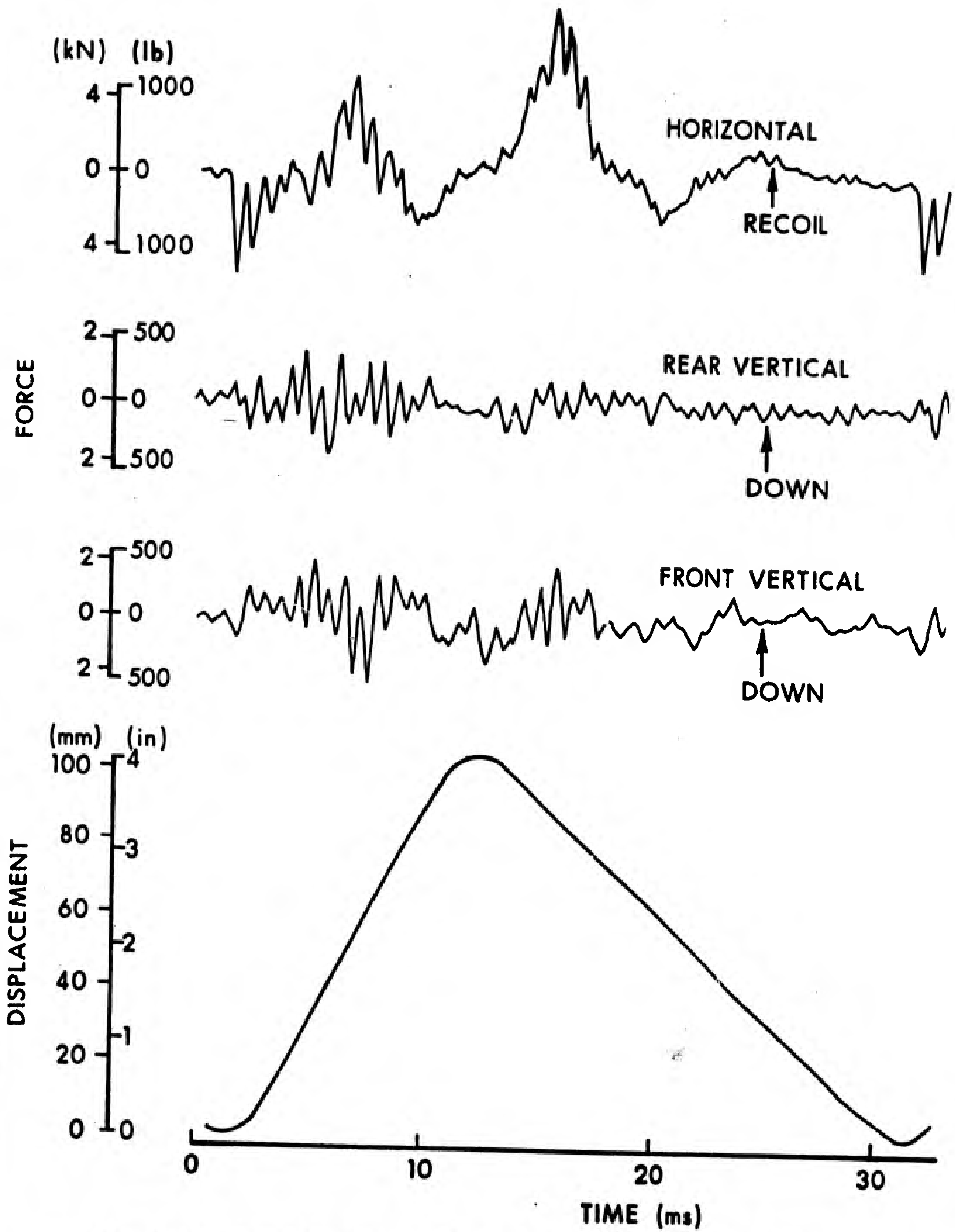

Figure 23. Trunnion Force and Bolt Carrier Displacement Records

TABLE IA. RESULTS OF TRUNNION FORCE MEASUREMENTS

Rounds	Horizontal Peak Forces (lb)				Rear Vertical Peak Forces (lb)				Front Vertical Peak Forces (lb)			
	Forward		Rearward		Up		Down		Up		Down	
	Av	σ	Av	σ	Av	σ	Av	σ	Av	σ	Av	σ
1 thru 10	1176	173	1864	243	541	169	419	71	467	69	496	103
11 thru 20	1279	135	2840	507	417	109	512	101	479	66	489	110

TABLE IB. RESULTS OF TRUNNION FORCE MEASUREMENTS

Rounds	Horizontal Peak Forces (kN)				Rear Vertical Peak Forces (kN)				Front Vertical Peak Forces (kN)			
	Forward		Rearward		Up		Down		Up		Down	
	Av	σ	Av	σ	Av	σ	Av	σ	Av	σ	Av	σ
1 thru 10	5.230	.770	8.291	1.081	2.406	.751	1.864	.316	2.077	.307	2.206	.458
11 thru 20	5.689	.600	12,632	2.255	1.855	.485	2.277	.449	2.130	.294	2.175	.489

Note: Measurements are for five, twenty-round bursts fired from a lubricated weapcn.

TABLE IIA. RESULTS OF RATE OF FIRE MEASUREMENTS

Rounds	Rate of Fire (rds/min) Av	σ
1 thru 10	1982	77
11 thru 20	2176	80

TABLE IIB. RESULTS OF RATE OF FIRE MEASUREMENTS

Rounds	Rate of Fire (rds/s) Av	σ
1 thru 10	33.03	1.3
11 thru 20	36.27	1.3

Note: Measurements are for five, twenty-round bursts fired from a lubricated weapon.

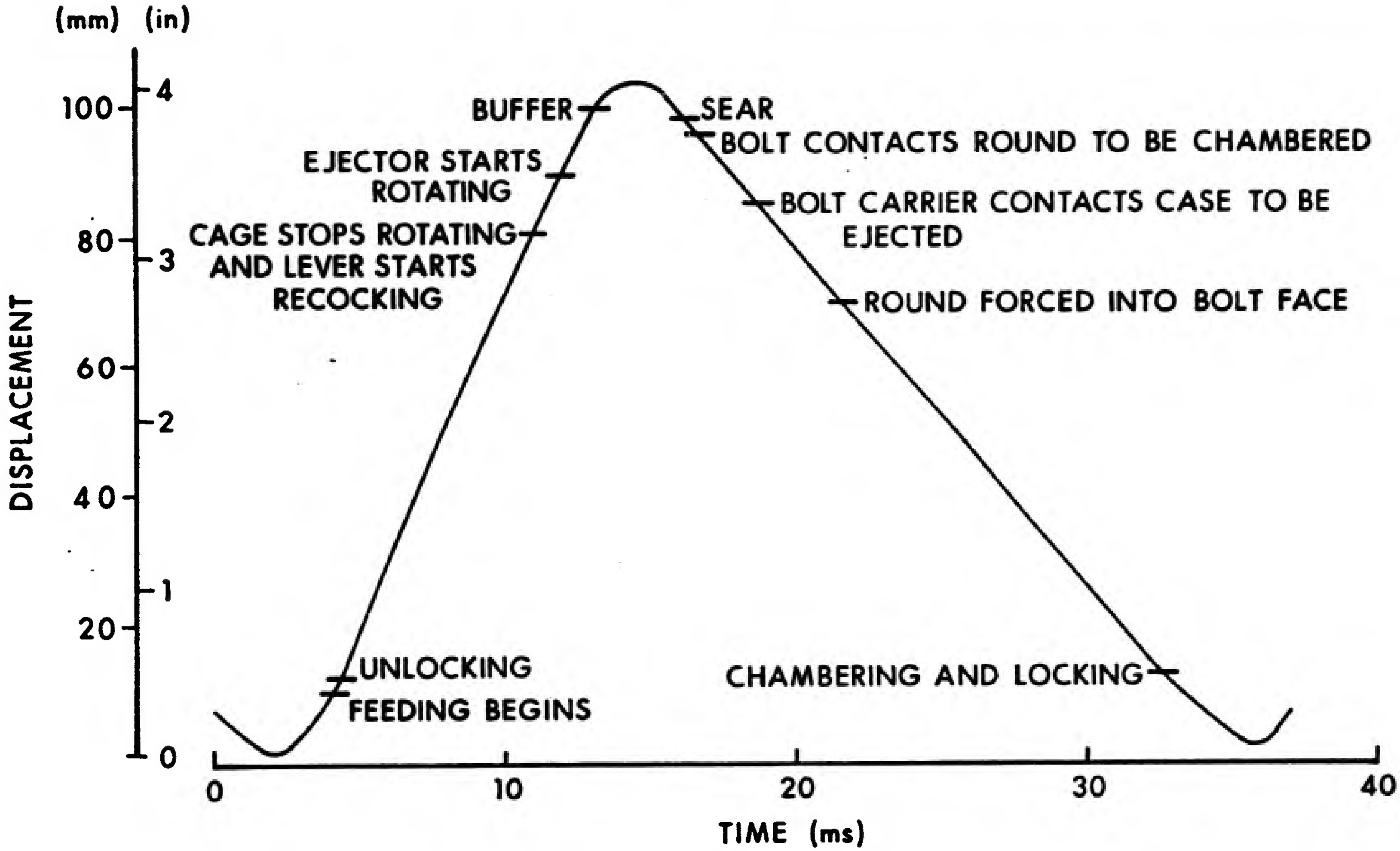

Figure 24. Displacement-time Record of the Bolt Carrier

TABLE IIIA. RESULTS OF BUFFER COMPRESSION MEASUREMENTS

Rounds	Buffer Compression (in.) Av	σ
1 thru 10	.163	.022
11 thru 20	.217	.018

TABLE IIIB. RESULTS OF BUFFER COMPRESSION MEASUREMENTS

Rounds	Buffer Compression (mm) Av	σ
1 thru 10	4.14	.559
11 thru 20	5.51	.457

Note: Measurements are for five, twenty-round bursts fired from a lubricated weapon.

TABLE IVA. RESULTS OF MUZZLE VELOCITY MEASUREMENTS

Rounds	Muzzle Velocity (ft/s) Av	σ
Five, twenty-round bursts	2699	32

TABLE IVB. RESULTS OF MUZZLE VELOCITY MEASUREMENTS

Rounds	Muzzle Velocity (m/s) Av	σ
Five, twenty-round bursts	822.6	9.8

bottoming limit of 0.235 in. (5.97 mm). Tables IIIA and IIIB show that the buffer compression for the first ten rounds of the twenty-round burst averaged 0.060 in. (1.52 mm) less than the compressions for the last ten rounds.

E. Projectile Velocity. The average muzzle velocity of the projectiles is given in Table IVA and IVB.

VI. CONCLUSIONS

Based on the results, the following conclusions were drawn.

A. Advantages.

1. The weapon is capable of firing at 2000 rds/min (33.33 rds/s).

2. The functioning of the weapon was good in that there were no misfires or malfunctions throughout the test.

3. The weapon is rugged and relatively short and has its center of gravity close to the centerline of the bore.

4. The rotary feed system takes the energy required for stripping the round from the rearward or power stroke instead of the forward stroke.

B. Disadvantages.

1. The impacts between the buffers and the bolt carrier are too severe, as shown by the large horizontal trunnion forces. Only over-design of the bolt, bolt carrier, receiver, and buffer system prevents parts from breaking frequently.

2. The locking system is not positive enough for complete safety. Locking is accomplished at the rear of the bolt on one edge only.

3. The feed mechanism is complicated and is dependent on several small springs for its operation.

4. The complicated feed system does not allow the weapon to be cleared in the event of a malfunction. The weapon must be disassembled with live ammunition in it to clear a jam.

5. Disassembly and assembly are not easy or straightforward because small parts spring out as certain components are removed.

ACKNOWLEDGMENT

The author is grateful to Mr. Carl Deweese for his assistance in performing the experimental studies.

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